Distribution of Salmonella contamination in two pig abattoirs

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Abstract

The distribution of *Salmonella* contamination on pig carcasses in relation to intestinal carriage was studied in one small pig abattoir(A) and in another high throughput abattoir(B). In abattoir A *Salmonellas* (*S.typhimurium* DTs 104,104B, 193, 208, RDNC, untypables, *S.panama, S.derby, S.goldcoast, S.kedougou*) were found in large intestinal contents of 22% of pigs after slaughter and on 25.7% of carcasses. Eleven of the 14 (78%) farm batches examined showed evidence of infection and *S.typhimurium* DT104 was found in 4 of these. In abattoir B 2211 pigs were examined during 8 visits. A wider range of *Salmonella* serotypes and phage types was found and the organism was isolated from 11.6% of large intestinal contents and 7.0% of carcasses. Seventy-two (48.6%) of 148 farm batches showed evidence of infection and *S.typhimurium* DTs 104 or 104B were present in 25 (16.9%) of these. In a separate study of contamination at various points in the slaughter process 85-100% of carcasses in both abattoirs were found to be contaminated by *Salmonella* immediately after slaughter, with measurable levels of up to 10^5cfu/0.1m^2 carcass. *Salmonella* was frequently isolated following scalding in abattoir A but this was uncommon in B. Survival of *Salmonellas* in the scald tank occurred when the water temperature fell below 60-61°C. *Salmonella* levels on carcasses increased during hair removal but was virtually eliminated by singeing in abattoir B. In abattoir A the effectiveness of singeing was reduced by an immediate post-singe wash. Further increases in *Salmonella* contamination occurred during evisceration and dressing and in both abattoirs. When the level of *Salmonella* carriage in pigs was low good slaughter practices were able to restrict carcass contamination but when a highly infected batch of pigs was processed the carcass contamination rate of that batch and one or two subsequent batches was also high. The relative importance of control of *Salmonella* at the farm compared with attempted control by hygienic slaughter is discussed.

Introduction

Although *Salmonella* infection in humans is a major problem worldwide the involvement of contaminated pig meat in this problem is unclear in most countries except Denmark (11), where a relatively large amount of lightly cooked pork is consumed. In other countries there have been occasional reports of *Salmonella* outbreaks in humans associated with pig meat, but these usually result from poor storage and food handling practices associated with large scale catering. (6)

Surveys of pig meat carried out at retail establishments suggests that a wide range of *Salmonellas* may be found (5) but information from large scale surveys on the prevalence and magnitude of contamination is not available in most countries. In the UK the proportion of pig farms where *Salmonella* is present and prevalence of *Salmonella* carriage in individual pigs is not known but surveys in other countries have suggested carcase contamination rates ranging from 1 to 28% (4,8). This paper describes work carried out in one small and one large abattoir to investigate the prevalence and distribution of *Salmonella* during the slaughter process.

Materials and Methods

Sampling regime

Samples were taken in one small older style abattoir (A) during one visit and in one large modern abattoir (B) on 8 separate visits over a six month period. Samples were taken from approximately 10% of each batch of pigs slaughtered throughout the day. Between 5 and 10g large intestinal contents were collected, after evisceration, into sterile plastic containers and carcase swabs were taken from 0.1m^2 carcase surface as a 10cm band running up from the neck alongside the ventral incision in the carcase. The carcases were vigorously swabbed with a sterile surgical gauze swab (Robinson Healthcare, Chesterfield, UK: No. 63024). Carcases were also sampled at 2 hourly intervals at various points in the slaughter process in order to study the patterns of contamination during slaughter. Samples were returned to the laboratory at ambient temperature and culture begun on the same day as collection.

Culture media

Samples were pre-enriched in Buffered Peptone Water (BPW; Oxoid CM509) at 37°C for 18 hours. 0.2ml was then inoculated into a petri dish containing 20ml of DIASSALM medium (LabM, Lab 537). After 24 and 48 hours incubation at 41.5°C subcultures were streaked onto Rambach agar (Merck 7500) using a 1µl disposable loop. The Rambach agar plates were incubated for 24 hours at 41.5°C and suspect *Salmonella* colonies confirmed by full serotyping. Semiquantative *Salmonella* estimations were carried out by vigorous shaking and decimal dilution of the sample in BPW immediately after sampling, and culturing each dilution for *Salmonella* as above.

Results

Table 1 shows the *Salmonella* isolation results from large intestinal contents and carcase swabs derived from the single visit to abattoir A. The table also shows the results from the visits to abattoir B in which the highest (B6) and the lowest (B7) prevalence of *Salmonella* was found. The combined results from the 8 visits to abattoir B.

In abattoir A pigs from 11 of the 14 (78.6%) farm batches showed evidence of *Salmonella* carriage and in 4 (28.6%) of the batches *S.typhimurium* DT104 or DT104B was present. *Salmonella* was found in the large intestinal contents of 66 of 300 (22.0%) of individual pigs and 10 (3.3%) of these isolates were DT104 or 104B. The prevalence of *Salmonella* in individual pigs within farm batches ranged from 0 to 65%. The carcase contamination rate associated with these pigs was 25.7% with 6.0% of the positive carcase carrying DT104 or DT104B.

On visit B6 to abattoir B *Salmonella* was found in 17/29 (58.6%) of farm batches and 24% of batches carried DT104 or DT104B. The *Salmonella* carriage rate in individual pigs was 21.5% with 5.2% of pigs carrying DT104 or 104B. Despite this relatively high level of *Salmonella* in individual pigs the contamination rate of carcases was only 7.8%, of which 4.1% were DT104 or 104B. On visit B7 the no. of farm batches in which *Salmonella* was found was only 5/20, with only one of these being associated with DT104. 22/309 (7.1%) of individual pigs were carrying *Salmonella* and only one of these isolates was *S.typhimurium* DT104. Only 3 (1.0%) of the 309 carcases were contaminated. In the overall study in abattoir B 256 of 2205 11.6%) of pigs were carrying *Salmonella* of which 3.2% had DT104 and 104B and 155/2211 (7.0%) of carcases were contaminated, 2.7% of these by DT104 or 104B.

Table 1: Salmonella isolation from large intestinal contents and carcass swabs of slaughter pigs in abattoirs

Abattoir code and visit no.	No. farm batches positive for Salmonella/ No. farms sampled (%) [No. farm batches positive for STM104 or 104B (%)]	Large intestinal samples: Mean no. +ve for Salmonella/No. samples taken (%) < > = No. DT104 or 104B	Carcass swabs: Mean no +ve for Salmonella/No. samples taken (%) < > = No. DT104 or 104B
A	11/14 (78.6) [4/14 (28.6)]	66 <10>/300 (22.0)	77 <18>/300 (25.7)
B6	17/29 (58.6) [7 (24.1)]	58 <14>/270 (21.5)	21 <11>/270 (7.8)
B7	5/20 (25.0) [1 (5.0)]	22 <1>/308 (7.1)	3 <0>/309 (1.0)
Total of 8 visits to abattoir B	83/185 (44.9) [30 (16.2)]	256 <71>/2205 (11.6) <3:2>	155 <60>/2211 (7.0)<2.72>

Abattoir visit B6 = visit with highest prevalence of *Salmonella* in pigs

Table 2: *Salmonellas* found in batches of pigs from individual farms in abattoir A

No. samples +ve for *Salmonella*/No. samples taken (%)

Farm Batch No.	Large intestinal contents	*Salmonella* serotypes/phagetype (No. of isolates of each type)	Carcase Swabs	*Salmonella* serotypes/phagetypes (No. of isolates of each type)
1	13/20 (65.0)	*S.derby* (8) *S.panama* (3) *S.typhimurium* DT193 (2)	10/20 (50.0)	*S.derby* (10)
2	11/20 (55.0)	*S.derby* (6) *S.panama* (3) *S.typhimurium* untypable (2)	5/20 (25.0)	*S.derby* (3) *S.panama* (1) *S.typhimurium* DT104 (2)
3	1/20 (5.0)	*S.derby* (1)	4/20 (20.0)	*S.panama* (4)
4	4/20 (20.0)	*S.panama* (2) *S.goldcoast* (1) *S.typhimurium* DT104 (1)	3/20 (15.0)	*S.typhimurium* DT104 (2) *S.panama* (1)
5	2/40 (5.0)	*S.derby* (2)	7/40 (17.5)	*S.panama* (4) *S.typhimurium* DT193 (1) DT104 (2)
6	0/20	-	1/20 (5.0)	*S.derby* (1)
7	0/20	-	3/20 (15.0)	*S.panama* (1) *S.typhimurium* DT104 (2)
8	10/20 (50.0)	*S.typhimurium* (RDNC) (10)	5/11 (45.4)	*S.panama* (3) *S.typhimurium* untypable (2)
9	7/20 (35.0)	*S.derby* (4) *S.kedougou* (1) *S.typhimurium* DT104 (2)	14/20 (70.0)	*S.derby* (1) *S.panama* (2) *S.typhimurium* DT193 (6), RDNC (4), untypable (4)
10	7/20 (35.0)	*S.derby* (4) *S.typhimurium* DT104 (3)	3/20 (15.0)	*S.panama* (2) *S.typhimurium* DT104 (1)
11	7/20 (35.0)	*S.derby* (3) *S.typhimurium* DT104 (3) 104B (1)	9/20 (45.0)	*S.derby* (5) *S.panama* (1) *S.typhimurium* DT104 (4), U302 (1)
12	1/20 (5.0)	*S.typhimurium* RDNC (1)	2/20 (10.0)	*S.typhimurium* DT104 (2)
13	0/20	-	3/20 (15.0)	*S.derby* (1) *S.typhimurium* DT104 (1), 193 (1)
14	3/20 (15.0)	*S.typhimurium* DT208 (3)	6/20 (30.0)	*S.panama* (1) *S.typhimurium* DT208 (3), 104 (2)

RDNC = *Salmonella typhimurium* which reacts with typing phages but produces no recognised lysis pattern

Table 2 shows a more detailed breakdown of the *Salmonellas* found in the individual batches of pigs delivered to abattoir A. There were only 4 of 14 batches in which no *Salmonella* was found and the prevalence of the organism in individual pigs from the infected batches ranged from 5 to 65%. Carcase contamination was found in all the batches and ranged from 5% to 70% of carcases. In some batches the *Salmonella* serotypes or phage types found on carcases matched those found in the gut of the pigs but in other batches this was not the case and the *Salmonellas* found reflected those occurring in previous batches slaughtered.

Table 3: *Salmonella* serotypes/phage types found in order of prevalence in Abattoir B

Salmonella serotype	No. of isolates from intestinal contents	*Salmonella* serotype	No. of isolates from intestinal contents
S.derby	62	*S.kedougou*	4
S.typhimurium DT104	60	*S.manhattan*	4
S.typhimurium untypable	44	*S.typhimurium* DT29	2
S.typhimurium DT193	14	*S.typhimurium* DT120	2
S.kimuenza	13	*S.typhimurium* DT12	1
S.typhimurium DT208	12	*S.typhimurium* DT181	1
S.typhimurium DT104B	11	*S.mbandaka*	1
S.typhimurium U302	10	*S.liverpool*	1
S.typhimurium DT106	8	*S.bovis-morbificans*	1
		S.yovokome	1

A wider range of *Salmonella* serotypes and *S.typhimurium* phage type was found in abattoir B than abattoir A, and these are listed in order of frequency of occurrence in Table 3. *Salmonella typhimurium* was the single most common serotype and DT104 was the predominant phage type. There was also a large proportion of untypable strains. *Salmonella derby* was the second most common serotype. Several of the less prevalent serotypes or phage types were not found on carcases but conversely single isolates of *S.panama* and *S.typhimurium* DT170 were found on carcases but not in gut contents.

Table 4: *Salmonella* isolation from carcases at various points in the slaughter process

(no. samples for positive *salmonella*/no. samples taken)

Sampling site	Total for Abattoir A	Mean salmonella estimation (cfu/0.1m^2)	Total for Abattoir B	Mean salmonella estimation (cfu/0.1m^2)
Post bleed	25/25 (100.0)	10^{4-5}	58/70 (82.9)	10^2
Post scald tank	14/25 (56.0)	10^2	4/70 (5.7)	NS
Post main dehairing machine	22/25 (88.0)	10^4	14/70 (20.0)	NS
Post secondary dehairing machine	8/25 (32.0)	10^2	17/40 (42.5)	NS
Post singe	10/25 (40.0)	10	0/50	NS
Post polisher	3/25 (12.0)	10	1/70 (1.4)	NS
Post evisceration	8/25 (32.0)	10^2	2/50 (4.0)	NS
Post splitting	8/25 (32.0)	10	7/50 (14.0)	NS
Post meat inspection	77/300 (25.7)	NS	25/200 (12.5)	10
Entrance to chiller	7/25 (28.0)	10^2	2/54 (3.7)	NS
Post chilling	3/25 (12.0)	NS	NS	NS

NS: not sampled

Table 4 shows the prevalence of *Salmonella* and a semi-quantitative estimation of the numbers of organisms found at various points on the slaughter line in both abattoirs there was a high prevalence (82.9-100%) of contamination after slaughter but numbers of organisms were higher in abattoir A. In abattoir B this was reduced to 5.7% after scalding but in abattoir A the reduction was only to 56%. Most of the positive carcases were from the first part of the day before the scald tank temperature reached 61-62°C.

The incidence of *Salmonella* increased again after passage through the main hair removing machines but in abattoir A passage through a further flail equipped with a continuous water jet was associated with a reduction in *Salmonella*. In abattoir B the flail had no intrinsic wash and the level of *Salmonella* increased at this point. After singeing, no *Salmonella* was found on carcases in abattoir B but singeing had little effect on contaminated carcases in abattoir A. This was because carcases were rapidly cooled by a cold water spray immediately after singeing. In abattoir A passage through a polisher flail, again equipped with a copious water spray, was associated with a reduction in *Salmonella* from 40% to 12% of carcases. One isolate was made after polishing in abattoir B. After evisceration the incidence of carcase contamination increased to 32% in abattoir A but only 4% in B. There was no further increase in abattoir A but in B the incidence increased after carcase splitting. Little *Salmonella* was found on carcases on entry to the chiller in abattoir B, following transit down a long passage. The incidence of *Salmonella* on carcases in abattoir A was reduced on carcases in the chiller but the chiller was not accessible for sampling in abattoir B.

Discussion

The work described in this paper is not representative as it was carried out in two abattoirs only, visited on a limited number of occasions. The results may also be biased by the inclusion of pigs originating from a number of large integrations in a high density pig area, but similar integrations occur in many other areas throughout the U.K., so the findings may perhaps provide an indication of the likely prevalence and *Salmonella* serotypes to be found more widely.

The overall prevalence of contaminated carcases in abattoir B was relatively low and compares favourably with results of similar studies in poultry processing plants. The numbers of *Salmonellas* found on finished carcases were also low but the high proportion of multiple antimicrobial resistant *Salmonella typhimurium* strains, particular DT104 and related strains, found is a matter for concern (9).

A wide range of *Salmonella* serotypes and phage types were found. *S.derby* was slightly more common than *S.typhimurium* DT104 in gut contents but the converse was true of carcases. It is possible that higher numbers of *Salmonellas* are found in the intestinal tract of pigs infected with DT104 and that this may result in more widespread contamination. The results shown in table two suggest the potential for transfer of salmonella types between batches of carcases. This effect seems to persist for one or two batches before the *Salmonella* is replaced by another strain. It is likely however that if several *Salmonella* negative batches followed an infected batch that the cross contamination would be identifiable for longer.

Although *Salmonella* contamination of the skin is widespread immediately after slaughter the scalding and singeing processes can reduce surface contamination of carcases to negligible levels (10). In abattoir A in this study the scald tank was slow in achieving its working temperature so in the first part of the day substantial contamination was found after scalding. The singeing process, which appeared to be highly effective in abattoir B, was also compromised in abattoir A by spraying carcases with cold water spray immediately after singeing. In contrast, the inclusion of water jets in the dehairing and polishing machines achieved a reduction in *Salmonella* which did not occur with the similar machines without sprays, in abattoir B. Most contamination after singeing originates during evisceration (10) and in our studies most of this appeared to originate from intestinal contents spilled from guts which had been damaged during removal. The frequency of this varied with the skill and state of mind of the operators on particular shifts. This was particularly noticeable on one visit to abattoir B during which frequent mechanical failures on the line resulted in considerable frustration and a deterioration in the standard of evisceration which let to the single occasion when the carcase contamination rate exceeded the intestinal carriage rate in that abattoir.

Good evisceration practice can be enhanced by procedures such as bagging the rectum and clamping the oesophagus and acidic carcase washes or steam treatment may also be used (7). If however there is a high prevalence of *Salmonella* in individual batches of pigs or even very high numbers of organisms in a single pig whose intestine is ruptured during evisceration, then control measures at the abattoir may not be sufficient to restrict the spread of contamination. It is therefore important to work towards a reduction of *Salmonella* in pigs presented for slaughter. This can only be achieved at farm level and fundamental to this is some form of monitoring programme so that the prevalence and types of *Salmonella* in breeding herds and commercial pig meat producers is known (2). Once this is in place the next decision is on how the results will be used. Countries with a relatively small livestock industry, such as Sweden, Finland and Norway, have been able to successfully maintain a *Salmonella* elimination policy (12). This is an expensive approach but may have International trade advantages. In Denmark, and more recently in other countries such as Ireland, National serological monitoring of pigs at slaughter using an ELISA test has been introduced. (1) Rigorous hygiene and biosecurity measures (3) are then put in place on farms which have a high seroprevalence of

Salmonella. This type of programme, if properly organised, is capable of reducing the prevalence of *Salmonella* in pigs but is also expensive to run and is more difficult to set up in a country such as the United Kingdom, where the pig and slaughter industries are independent and diverse, the average herd size is large and the use of purchased replacement breeding stock, (which may also be more susceptible to endemic *Salmonellas* when introduced to a contaminated environment) is common. It would appear that the most likely approach to reduction of *Salmonella* in pig meat in the U.K. will be led by the major retailers through individual abattoirs and this is to be welcomed. It would however be advisable to carry out more research to compare pig and human *Salmonella* strains so the contribution of pig meat to human disease can be determined.

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